SUPPLEMENT.

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The Royal School of Mines, Jermyn Street.

Mr. WARINGTON SMYTH'S LECTURES.

[FROM NOTES BY OUR OWN REPORTER.]

Lecture XLII (*Continued*).—The old fashioned "hund," or wagon, in use in Germany and Hungary was, no doubt, a great step in advance upon the plan of carrying the ore in baskets from the place whence it was excavated to the shaft for removal to the surface; but it was also the pioneer of that system of railway conveyance underground which has changed the whole system of mining. The next move was the adoption of wooden rails, such as even now may be seen in some of the lead mines of Alston Moor. This kind of arrangement came to be very largely used in the latter part of the last century, and is mentioned by French visitors to some of our mines as the beginning of a new phase. The next step beyond wooden rails and flat wheels is obviously that of sharp wheels and flanges; but intermediately several other forms were tried, as, for instance, a single centre line of rail, with a wheel flanged on both sides to keep the wagon straight and on the tram-plates. The introduction of iron rails was not quite contemporaneous in the several countries, and a very few people still argue for the old system in preference to the method now generally adopted of flanged wheels with a narrow rail. Broad wheels are still employed in some mines, from the expense which would be incurred by changing the whole of the plant of a mine. Wrought-iron then was gradually introduced instead of cast-iron, which was found to be too brittle. The strength of the rail must be proportioned to the scale of the works, and the weight which the wagons carry, their size, &c. The guage varies considerably, from 12 in., measured from centre to centre of the rails employed, as in the hematite mines of Ulverstone, where they use narrow wagons, from 2 to 2½ ft., until in some quarries in the West of England the 6-feet broad guage rails of the Great Western are adopted. The rails are generally made of rolled iron and steel. Some consist simply of a square or oblong bar of wrought-iron, but in this form its narrow head is apt to cut the wheel. It is better to have a T-shaped rail, to give a greater bearing.

The system of wagons and rails is chiefly elaborated at the coal mines where such large quantities of material have to be transported. In the metalliferous mines they still trust a good deal to hand barrows, if it is only to convey the mineral 100 or 200 yards, but very often no more than three or four men may be driving at the end, and the total quantity of mineral is so small that it is not worth while laying down rails. It is often very useful to have rails laid in every alternate level, so that the mineral can be thrown down from the one above into the level which has a system of rails, and thus be conveyed to the shaft. In collieries there is now always a rolly or trolly-way along the main lines, but still the putting of coal from the face of the working to the main lines must be done by hand. Where the coal is low and thin, and the rise and fall considerable, the wagons may sometimes be made to run down an incline, and pull up empty ones. If very low the "hurrying" is generally done by two boys, one pulling the wagon with a chain, and the other pushing, frequently with his head. Many heart-rending pictures of boys of tender age at this work have been drawn by humanitarians, but the nature of the case often prevents the use of any other means; the boys themselves do not mind it, and they grow up into strong and hearty men. Wherever it is possible, however, this low work should be prevented. It is bad enough for a visitor to creep along a level 2 feet high without having to push anything, and such labour is, therefore, neither economical nor desirable. In the North of England large baskets of wicker-work were formerly used to convey the coal to the hoist. These were filled, and then the sides raised by three, four, or five iron rings placed one above another to keep in the coal. This system is also to be seen in South Staffordshire, but the method now generally used is to move the same wagon all the way from the face of the workings to the surface, and thus to prevent as far as possible any unnecessary loading and unloading. These wagons may be 3 ft. by 2½ ft. wide, and 2 to 3 ft. deep, but they vary according to the nature of the mineral; they generally contain about 11 cwts. In South Wales trucks are used containing from 1 to 1½ ton. If these get off the rails several men are required to replace them, and thus the whole traffic may be seriously impeded. Even if they contain only 11 cwts. it requires a strong man to manage them. In some large mines, in order to draw the wagons from 80 to 100 horses are kept, and a veterinary surgeon to look after them. In these cases the mine owner should also have land and grow his own hay, oats, and straw. If many horses are kept great cleanliness is requisite to prevent epidemics, and many underground stables are remarkably clean and well ventilated. As the works extend the supervision of so many horses becomes very onerous, and it was attempted very early, and in many instances successfully, to introduce steam power instead of horse labour. The late Mr. Nicholas Wood wrote two experimental papers on different modes of conveyance underground, and compared the various methods in use. He showed that if you wanted to employ such an amount of force in pulling in empty wagons as in pulling out the full ones, the latter should come down an incline of from 1 in 160 to 1 in 130. The strain then will be about the same going in as coming out. And as regards carriage generally, that that is the best inclination to be given to the main roads. By these experiments it was shown also that horse power was doing an amazingly small amount of the work it ought to do, for the simple reason that it is impossible to keep underground roads in the same condition of those above ground. Thus, at the surface, while a horse was capable of dragging 133 tons one mile per day, it would only on the underground roads do half of that amount, and in some cases a third, and in others only a fifth. These results furnished excellent reasons for adopting steam power and rope traction, and it soon began to be carried out with great success in the North Country collieries. The engines are stationary, and the trains of wagons, consisting of 20, 30, or even 40 tubs, are attached to the extremity of a rope, which passes round a large drum, and thus draws the load towards the shaft. In this plan the train also drags behind it a tail-rope to another drum attached to the engine, and so as the full wagons go away from the workings the empty ones are drawn back to them to be re-filled. Another plan is that of the endless rope or endless chain, which keeps constantly moving in one direction, and the full trucks are hooked on at one end, and the empty ones at the other, both being unhooked by a simple contrivance on arriving at their destination. The question as to which of these plans is the better has not yet been decided. At present, in Lancashire, the endless rope is the favourite, and in the North Country the tail rope is generally employed. A good deal, however, depends upon the inclination of the seam. If that, for instance, is (say) 1 in 30, the wagons may run down of their own accord, as it were, or rather by natural gravitation, but to pull them up that inclination engine power will be requisite, and there may be difficulties in making arrangements for it. In other cases, when working down a rise towards the drift, the full wagons will run down with sufficient force to draw up the empty wagons, but to do that the incline must not be less than 1 in 28.

Lecture XLIII.—Our object in the last lecture was to look at some of the successive steps by which the horizontal carriage or transport of the minerals along the levels was effected, and had been from time to time improved. It is true that I only alluded to dry levels, but it may be as well to mention that at one time much attention was paid in certain districts to the conveyance of minerals by boats in levels, which might be called subterranean canals. The first great change you will recollect was effected by the introduction of iron rails in Germany, just about the time at which wooden rails were introduced at Alston Moor; and that pretty early in the last century the flange was suggested as an improvement. Its application was various, but at last it come to be cast with the wheel as a part of it. Then came the use of edged wheels of various forms, in which the wheel was thrown to a greater height, and the rails laid on chairs—a very considerable improvement, as it enabled the larger collieries to dispense with the use of horses, which had been troublesome, expensive, and less effective. This in the North of England led to the erection of stationary engines, by which the wagons were drawn along the levels either by a main or tail-rope, or by an endless chain, under which the speed attained is so great that, without going into details, I may mention that trains of tubs, from 20 to 60 in number, are drawn along at a velocity of something like a mile in six minutes, giving the miners the power to work on two or three sides of a shaft, and bringing out an enormous quantity of coal. Thus, the use of full-grown horses has gradually gone out; and in narrow seams and workings, where "hurriers" only were formerly employed, small ponies (of which there is a large importation from Shetland for the purpose) are used to draw the skips along these low levels to the engine planes. Canal conveyance was advocated by the great engineer, Smeaton and others, as a great improvement over ordinary roads for heavy traffic, and no doubt it was so; but it was conceived that it might also prove of great advantage underground. In the last century, therefore, at several places levels were driven of extra size, puddled, and converted into canals. In Shropshire there is now a long level of this kind, which was designed to answer the double purpose of an adit and a means of conveyance, and which is called the "boat level." It was thought that, considering the large quantity of water which these levels often bring out, it would be a moderately cheap mode (where the geological conditions permitted) of bringing the valuable minerals to daylight. The boats are made flat and long, and the motive power is obtained by means of a flat rope along the roof of the level, pulled at by a man who crouches in the bow of the boat. In some of these canals the mode of propulsion is not a little curious; for instance, in some places men called "leggers" lie on their backs on the top of the cargo, and push the boat along by the action of their feet upon the roof. In one or two of these ancient canals, as, for instance, at Holywell, in Flintshire, visitors are floated into the interior of the mine, but they are often so close to the roof as to run a risk, if due care were not taken, to scrape their noses. At the celebrated Worsley Colliery, in South Lancashire, a water level of this kind is carried in to a distance of several thousand yards; it is 8 ft. high, and 9 ft. wide; the roof is arched at places, and the thing is well done, but there is a difficulty of keeping up 4 or 5 ft. of water. In some of the Belgian mines, in the valley of Liége, in the Hartz mines, and at Clausthal, they have these canals, but now-a-days they have often a rail running side by side with them. The whole value of such arrangements, it is obvious, must depend upon whether the use of an adit in this way will save the cost of raising the mineral to the top of the hill, and whether the conditions of the traffic will be best met at the point thus reached. The experience, however, of the last 30 years has established the rule that it is not worth while to go out of one's way to make such canals. Their decline was, no doubt, hastened by the exceeding slowness with which the mineral was moved, bearing no comparison with that of tramroads and railways. And so in the Hartz, where there is a canal 1000 fms. in length, it would not now be tolerated if the question of local convenience could be left out. We may, therefore, take it as a matter of certainty that very few water levels of this kind are likely to be made in future.

In passing on to other mechanical details required for mines, we come next to the raising of the mineral, or of water, in the shaft. Here we approach a great and complicated crowd of apparatus, and to avoid confusion it will be well to fix our attention separately on the different classes of machines employed, and the improvements which have been made in them. These classes for that purpose may be conveniently divided into three—first, those moved by man or horse power; secondly, those moved by water power; and thirdly, by steam power. And we will first take a general view of the machines employed; next, their localities; and then look a little closer into the construction of those which come most frequently into use. When muscular force is employed—that is to say, manual labour or horse labour—it is brought to bear by the simple application of what are generally known as the lever and the axle. The principle of the ordinary windlass and its numerous varieties will be found in the whim or horse-gin, so largely employed in the metalliferous districts, and under certain circumstances in the coal districts. Very simple applications are also brought into play by water power, and minerals raised from considerable depths by what are called water balances, which are largely employed in South Wales and the slate quarries in North Wales, and in many other places, although not on so large a scale. In this arrangement a large wheel (say, 9 feet in diameter) is erected over two shafts or one shaft divided into two. Round the wheel is passed a strong iron chain, one end of which hangs down one shaft, and the other end down the second. At the end of one is the cage for coal, and at the end of the other a box containing a large weight of water. A water pipe of sufficient dimensions is placed between the two shafts, communicating with a reservoir at the surface. Supposing, then, the cage full of coal to be at the bottom, the water-box at the top is filled from the pipe until it overbalances the load, and brings it up to the surface. The water is then got rid of by a convenient arrangement, and the box becomes so much lighter than the empty cage that the latter descends to be re-filled, and the process is repeated. This is an extremely economical method if there are facilities for getting rid of the water which is thus poured into the mine—facilities which are permanently present in the slate quarries, for instance, which I have just mentioned. Nevertheless, this is a slow process, and except in districts where it is worked on a large scale, there has not been so much attention paid to the water balance system as it deserves, but where there is plenty of water, and speed is not a great object, its application will be found advantageous, even if the water has to be pumped up. This may seem absurd, but it is not so in reality, because a winding-engine cannot be worked by steam so economically as a pumping-engine. The more common application of water power is that effected by the use of the water-wheel, which has been in use from the very earliest times, and under circumstances in which, as we see in the ancient book of Agricola, the water is pumped up to the top of the wheel, and poured over it. In other cases, what is called a "flop-jack," where the weight has not to be raised any considerable distance, is used. This is a strong beam balanced on a centre. To one extremity the pump-rods are fastened, and attached to the other is a strong wooden box. Into the latter a considerable weight of water is poured, which by its gravity raises the rods on the other side 8 or 10 in. at a time, and so in this way, by means of lifts of from 8 to 10 inches, the pumps are worked to a depth of from 30 to 40 fms., and the great expense of water-wheels and steam-engines is avoided. The most unsatisfactory water-wheels are those found in the South of Europe. These are of small diameter, fitted with a series of buckets, on which the water is allowed to inpinge at a considerable velocity, and so the wheel is turned, and the weight brought up. In most districts, however, where economy is looked to, it is usual to employ one of three classes of wheels. First, the undershot wheel, which is mostly 3 or 4 ft. in diameter, and in which the water impinges on the under part of the periphery of the wheel; secondly, the breast wheel, where the water is delivered at or near the middle of the wheel into buckets projecting from the circumference; and, lastly, the overshot wheel, in which the water is led to a certain height above to a trough, from whence it is delivered on the higher part of the wheel, and by which means the greater part of the power is due to the actual weight of the water. The buckets into which the water is received have given rise to much disputing as to which form is the best to secure the advantage of of the full weight of the water. Another point is the arrangement by which the water runs off below, so as to prevent any weighting or counter action on the wheel. Besides these another sort has latterly come into play, called the high breast wheel, which is a modification of the overshot principle. In metalliferous mining, where they get moderate streams of water with sufficient fall, the overshot wheels are preferred, and mostly employed, but each, according to circumstances, has its advocates. There are a few points connected with construction that are worth a few minutes attention. The axle is the most expensive part of the wheel, being one of the principal portions, and upon it lies all the strain in working. The cost of an axle of a wheel is considerable, and I may mention as an instance that the axle of the wheel at the well-known lead mine at Laxey, in the Isle of Man, cost no less than 500*l.* This wheel is 72 ft. in diameter, and the largest in the world. Supposing we have a large fall of water, we must proportion the height of the wheel to the fall, and it will also be necessary to have some depth for the tail water, to prevent the wheel from dipping into it, and thus occasioning a loss of power.

The overshot wheel consists principally of an axle or axis, a centre boss, the arms, and the circumference, on which the buckets are placed; the circumference is usually termed the shrouding, or rim of the wheel. The axle of a wooden wheel is made of a stout piece of oak, and is supplied with gudgeons, which are fastened in a mortice cut towards the extremity of the axle, and afterwards hooped round with a piece of wrought-iron, to bind it closely together. Of the iron wheels, which are largely used in this country, the axles are either made of cast or wrought-iron. The cast-iron axles are made in a great variety of forms; sometimes they are cast solid, and in some instances they are ribbed, in order to give them additional strength, while in other cases large hollow castings are employed. Of late years the axles have been made of wrought instead of cast-iron, because, although the first cost is greater, they have the advantage of being less bulky, and, therefore, more convenient for shipment, and there is the further advantage of their being of a more tenacious character, and consequently more durable. In case of heavy work the bearing should rest upon brasses, and these should be fitted as closely as possible. The old wooden wheel used to be made of main or master arms and auxiliary arms. If the whole of the wheel is made of wood the rim is generally oak, and built together in segments, which are usually strengthened at the joints by iron plates. The most convenient kind are those made partly of cast-iron and partly of wood. In the last century, when the pumping-engine was in a more advanced state than the rotary-engine, and when wheels were very extensively employed at the collieries, pumping-engines were erected for the sole purpose of lifting the water to a sufficient height to work the wheels. The buckets used with the wheels are constructed in a variety of forms; but the principal point to be studied is to give them the greatest capacity for holding water, by arranging them at the proper angle, and allowing the weight to act upon as large a portion of the circumference as possible. One difficulty we often meet with in connection with the buckets is the tendency of the air which lodged in the bottom to exclude some of the water, but this has been obviated by Mr. William Fairbairn, the well-known engineer, who has devised a very ingenious plan to "ventilate" the buckets, and so allow by perforations in the buckets the escape of the air.

THE NEW METHODS OF MANUFACTURING STEEL.*

BY DR. B. H. PAUL.

The manufacture of steel is an industry of such great and growing importance, and any proposed improvements of that manufacture admit of, or rather demand, consideration from so many different points of view that in treating of the late progress of this industry I cannot pretend to attempt more than giving a brief statement of those novel methods of manufacturing steel which have lately been proposed, and at the same time pointing out, as a chemist, what appear to be the distinctive features of these various methods, and their relations to those hitherto practised. For the chief interest of this evening's proceedings, however, I shall look to the discussion which I hope will ensue, and to the remarks which those practically engaged in producing and using steel may be disposed to offer.

That particular kind of metallic iron which is termed steel, and which differs from ordinary malleable iron in combining very high degrees of tenacity and malleability, with a capacity of being hardened and tempered that common bar-iron does not possess, differs also still more widely from cast-iron, which is much more readily fusible, has considerably less tensile strength, and is not at all malleable. The great value of this difference in the mechanical characteristics of the several forms of metallic iron in their application to different purposes is too well known to require further mention. It is merely the chemical nature of that difference which I purpose to refer to. This consists in the variation of the amount of carbon in the metal, or, at any rate, those differences in the nature and qualities of metallic iron which are represented by the terms malleable iron, steel, and cast-iron, are invariably found to be accompanied by corresponding differences in the amount of carbon the metal contains. With pure iron, speaking chemically, we are practically unacquainted, and the very high-class malleable iron, such as Swedish, is the nearest approximation to it. Among the three distinct kinds of iron, malleable iron invariably contains the smallest amount of carbon. Cast-iron contains the largest amount, and steel is, in this respect, intermediate between the two. The distinction between these three forms of metallic iron is, however, by no means absolute, and while from a mechanical point of view it consists mainly in the degree and proportion in which certain characters are associated together, so in like manner from a chemical point of view, the relative magnitude of those characters and the relations they bear to each other are connected with the amount of carbon. Accordingly there may be numerous varieties of steel approximating more or less to malleable iron or to cast-iron. The smaller the amount of carbon the closer is the resemblance to ordinary malleable iron, and the larger the amount of carbon the closer is the approximation to cast-iron. As a general rule, however, the limits within which the amount of carbon is considered to vary in the several forms of metallic iron may be arbitrarily fixed. When it is less than about 0·65 per cent. the metal is either destitute of the capability of being hardened and tempered, or it possesses that capability only in a very slight degree. This amount of carbon marks the limit between malleable iron and steel. On the other hand, when the carbon amounts to 1·75 per cent. the metal is capable of being made very hard; but its tenacity is comparatively small, and this is the limit between steel and cast-iron. The relation between the characters of metallic iron and the amount of carbon it contains is probably not invariable, but subject to be influenced by the presence of other substances; and though there is some evidence to warrant this opinion, it is quite inadequate to elucidate the question so fully as its importance deserves. So far as carbon alone is concerned in affecting the character of steel, 1·5 per cent. appears to be the amount with which the metal presents the maximum combination of tenacity and capability of being hardened and tempered.

It will be evident from what has been said that steel differs from ordinary bar-iron mainly in containing a larger amount of carbon than bar-iron does; and if it differ from cast-iron in containing less carbon there is a possibility of producing steel either from malleable iron by increasing its amount of carbon, or from cast-iron by reducing the amount of carbon; and, in fact, it is by one or other of these two general methods of procedure that steel is generally produced. I shall, therefore, classify the several new methods to be referred to according as they involve carburation or decarburation of the material operated upon. There is also another method of producing steel by direct treatment of iron ores, which has long been practised in a primitive manner and to a small extent; but though it has hitherto had only in certain localities an exceptional value, it may yet become very important; for now that the applications of steel to numerous purposes are increasing to such an extent that economic methods of producing that form of metallic iron are among the foremost desiderata of the time, any means by which the cost of production, the consumption of fuel in melting, and the expenditure of labour in operations can be reduced, are calculated to be of vast influence in the development of this industry.

Taking first in order the methods of carburation, it will be unnecessary here to say more of the production of steel by cementation than to point out the necessity of employing for this purpose malleable iron of high quality as regards chemical purity. For that reason most of the bar-iron produced in this kingdom is excluded from application for steel making by that method; and as it is the one which has been, until recently, most practised, the iron used has been chiefly imported from Sweden.

The carburation of malleable iron by melting it with carbonaceous materials is at least one of the oldest methods of making steel. The Indian wootz is thus produced. Reaumur speaks of having made steel in this way in 1722. In the year 1800 David Mushet obtained a patent for the manufacture of steel by melting malleable iron with proportions of charcoal regulated according to the character of steel

* Read at the Inventors' Institute.

required. Heath's improvements in the manufacture of steel, about 1839, were in part of this nature, and were, probably, to some extent suggested by the Indian practice of making wootz.

In 1855 Dr. Price and Mr. Nicholson obtained a patent for making steel by melting malleable iron with suitable proportions of refined pig-iron. In the following year Gentle Brown obtained a patent for effecting the same object by melting malleable iron with charcoal pig-iron; and in 1862 Mr. Attwood obtained a patent for making steel by melting malleable iron with pig-iron, giving a preference to that kind called "spiegel" iron.

These and numerous other attempts have been made since that time to produce steel in this way, but they have invariably proved unsuccessful, except on a small scale in crucibles; and this result was, in a great measure, due to the circumstance that, in melting large quantities of malleable iron in the ordinary reverberatory furnace, the production of the necessary high temperature was attended with too much oxidation of the metal operated upon, while at the same time the consumption of the fuel was too great, and the destruction of the furnaces, in consequence of the great heat, was very considerable.

The introduction of the regenerative gas-furnace invented by Mr. Siemens first afforded a means of overcoming the difficulties attendant upon the production of steel by this method, otherwise than by melting in crucibles. Messrs. Martin, of the Sireuil Works, in France, appear to have been the first to succeed, about the year 1864, in producing steel by this means, and they have since obtained patents for several minor details of the operation. The essential feature of the success attained is, however, the application of the regenerative gas-furnace, which admits of a sufficiently high temperature being produced, while the atmosphere of the furnace is kept so free from surplus oxygen that it does not cause oxidation of the metal. Shortly afterwards Mr. Siemens erected some experimental works at Birmingham with these furnaces, for the purpose of demonstrating their efficiency for making steel by this method. He states that, while in Sheffield the ordinary consumption of fuel in making crucible steel amounts to between 3 and 4 tons of coke per ton of steel, the consumption with the regenerative gas-furnace is not more than from 15 to 20 cwts. of common coal slack per ton of steel, and in making steel without crucibles not more than 10 to 12 cwts., the difference in the cost of the two kinds of fuel being at the rate of 14s. or 15s. per ton. I am not aware that these furnaces have yet been adopted elsewhere in this country for making steel, though the results stated by Mr. Siemens tend to show that their use would be accompanied with great advantage.*

The material operated upon in these furnaces might be any kind of malleable iron, but hitherto old malleable iron rails have been chiefly used. These are introduced into the furnace through a kind of hopper, with their ends resting upon the hearth, and dipping into a bath of melted cast-iron, which serves to carburate the iron so far that it is rendered more fusible and gradually melts down, furnishing, after a certain time, a mass of melted steel. It is probable that in this operation the atmosphere of the furnace, being free from the surplus oxygen present in an ordinary reverberatory furnace, and relatively much more highly carburetted, may itself contribute in part to the production of steel by direct carburation of the malleable iron; for carburetted gases are, at a high temperature, capable of transmitting part of their carbon to iron, much in the same manner as in the ordinary process of cementation with charcoal. The production of steel in such a manner was made the subject of a patent by Mr. C. Macintosh, in 1825, the material proposed to be used being ordinary coal gas. It is also possible that in the Siemens furnace the carbonic acid resulting from the combination of the gaseous fuel may contribute in some deree to the carburation of the malleable iron; but, whatever may be the precise nature of the process in detail, there can be no doubt as to the practical advantage of the non-oxidising nature of the gaseous atmosphere in the furnace. In consequence of this and of the small consumption of fuel, the charge of metal may be kept for some length of time in a melted state without suffering injury, the progress of the operation may be ascertained by removing from time to time a sample of the metal, and the character of the product may be regulated as required. For the same reason, also, opportunity is offered to operate upon the melted charge with fluxes or materials capable of effecting its purification from such admixtures of phosphorus, sulphur, &c., as may be detrimental to the quality of the metal, but in this direction little appears yet to have been done.

Another new method of producing steel by the carburation of malleable iron has been invented by Mr. Gjers, of Middlesborough-on-Tees. According to his plan, a Siemens furnace is used, the hopper before referred to being replaced by a shaft heated externally, and into which is charged a mixture of puddled iron in small fragments, with suitable proportions of charcoal and iron ore containing manganese. As these materials descend in the shaft a fresh charge is supplied from above, and the melted metal flows out into the hearth of the furnace.

I must here mention briefly a method of producing steel which, though not new, is closely analogous to that of melting malleable iron and cast-iron together. This is the immersion of malleable iron in melted cast-iron at a temperature insufficient to melt the former. This method appears to have been practised at remote periods in Italy and in Elba, though I cannot learn of any more recent instance of its application. The nature of the process would be much the same as in cementation with charcoal.

Passing now to the methods of producing steel by decarburising cast-iron, I must first mention that steel has long been produced in this way in the South of Europe and in Westphalia by fining cast-iron under a blast in a hearth fired with charcoal. In this way the carbon is gradually burnt out of the semi-fused iron until its amount is sufficiently reduced for the metal to have the character of steel. The production of steel by puddling is an operation of a similar nature. It is stated to have been practised so far back as 1835 in Carinthia, and in 1845 Bischof made puddled steel at Mägdesprung, in the Hartz. Somewhat later this method was introduced into Westphalia; it was then adopted in France, and in England at the Mersey Steel and Iron Works, also by the Lowmoor Company, and subsequently elsewhere. The production of steel by puddling consists essentially in stopping the process of decarburation at an earlier stage than in the production of ordinary malleable iron by the same method. The advantage of this method probably consists mainly in the fact that in puddling there is a considerable elimination of those impurities, such as phosphorus, and perhaps sulphur, which are considered to be detrimental to the quality of the metal.

Another method of decarbonising cast-iron consists in melting it with iron ore, or some form of oxide of iron, in such proportions that by the reduction of the latter in oxygen may remove just so much of the carbon as to yield steel. Patents for this method were obtained by Wood in 1761, and by Uchatius in 1855. It is said to be successfully practised in Sweden.

In 1722 Reaumur made known the fact that cast-iron could be decarburised and converted into steel without melting, by heating it for some time surrounded by oxide of iron. In 1804 a patent was obtained by Lucas for the application of this method, and more recently Messrs. Brown and Lennox have patented its application to the manufacture of such articles as stirrups, pulley-blocks, &c.

The Bessemer method of producing steel, first publicly introduced in 1856, consists, as is now well known, in decarburising cast-iron by blowing air through it when in a melted state; and this method has passed so far beyond the condition of a novelty that it is unnecessary to say more about it now than to state that, after some period of struggling against much opposition and many difficulties, it has at length come into very general and extensive use, attaining that success which is the best recommendation. Its merits and demerits are well known, and its introduction marks an epoch in the history of steel manufacture analogous to the invention of puddling by Cort.

A method of this class, and of more recent date, which claims to be a rival with, or even superior to, the Bessemer method, is that for which a patent was obtained by Mr. Heaton, of the Langley Mills, near Nottingham. According to this method, which in point of novelty takes precedence over others, the decarburation of cast-iron is effected by means of nitrate of, soda mixed with sand and lime in such proportions as to mitigate the mechanical effect of the explosive decomposition of the nitrate on its coming in contact with the melted cast-iron. The Heaton converter consists of a cylindrical iron vessel lined with fire-clay, in the bottom of which may be attached a kind of pot containing the charge of nitrate of soda, lime, and sand, &c. This charge is covered with a perforated plate of cast-iron, fitting closely within the converter. Melted cast-iron is then run upon the top of the iron plate, which melts, and allows the metal to come in contact with the mixture of nitrate, lime, and sand. According to the description of Prof. Miller, a reaction commences in a very short time, a moderate quantity of brown nitrous fumes escape, followed by a copious discharge of dark vapour, carrying out a portion of melted slag. After the lapse of five or six minutes there is a violent deflagration, attended with a loud roaring noise, and a burst of brilliant yellow flame, lasting for about a minute and a half. When this has subsided the contents of the converter are emptied out on the ground, and the pasty mass of metal hammered into a cake. This is either reheated in a reverberatory furnace and converted with the hammer into blooms, which are then rolled into bars of "steel-iron," or the cakes of metal are broken up and melted in crucibles to form cast-steel. The merits of this method have recently been the subject of much controversy and dispute, into the details of which it is unnecessary that I should enter now. One of the chief advantages claimed for it in contradistinction to other methods is that it may be applied to the manufacture of "excellent steel from coarse, low-priced brands of crude pig-iron, rich in phosphorus and sulphur, from which no other known process, not even Bessemer's, enables steel of commercial value to be produced at all." If this claim should be borne out by practical experience, the Heaton method would probably be of incalculable value for the manufacture of steel from the vast sources of iron ore in the Cleveland and Northamptonshire districts. The analyses, by Dr. Miller and myself, of steel certified to have been made by this method from various brands of inferior phosphuretted pig-iron, have shown that an elimination of phosphorus is effected by the Heaton method, and though those analyses have also disclosed the fact that the metal thus produced still retains a considerable amount of phosphorus, the results of the trials to which it has been subjected by Mr. Kirkaldy prove that it possesses great tensile strength and other good mechanical qualities, which, so far as they go, would indicate that the metal is of good quality. To establish this point satisfactorily, however, much further evidence is still required.

In regard to the preference claimed exclusively for this method by reason of its applicability to inferior pig-iron containing phosphorus, it is proper to state that this can scarcely be maintained altogether, for the method of puddling now practised to some considerable extent also effects elimination of phosphorus, and is, therefore, in this respect applicable to inferior brands of pig-iron. However, this is a very important feature of the Heaton method, and if in other respects it should prove successful, that circumstance would render it applicable to the production of steel from a large class of pig-iron which cannot be used for this purpose by the Bessemer method, for which I believe 0·1 per cent. of phosphorus is the maximum amount that can be allowed to exist in the pig-iron used. This necessity of using pig-iron practically free from phosphorus is certainly a serious limitation to the applicability of the Bessemer method, and one which has a special importance for this country, where the greater part, though by no means all, the iron ores available yield pig-iron containing a larger amount of phosphorus.

It now only remains for me to notice the third general method of producing steel direct from iron ore by one operation. This method, like those already described, has long been practised, as in the old Catalan forge, and numerous unsuccessful attempts have been made at various times to carry it out in a manner more accordant with modern requirements. This method is, however, still in an embryo condition, and it is only quite recently that by the application of the Siemens regenerative gas furnace for this purpose there has been reason to look for any more favourable results. The arrangement adopted by Mr. Siemens consists of a cylindrical hopper heated externally, which is charged with iron ore and connected with a gas furnace in such a way that the reducing gas acts upon the ore and converts it into the state of a metallic sponge. This partially reduced spongy metal, descending in the hopper, comes in contact with a bath of melted pig-iron on the hearth of the furnace, whereby its reduction is completed, and it dissolves in the pig-iron, forming steel, while the earthy constituents of the ore are melted and separate as slag. Mr. Siemens prefers to use a mixture of hematite and spathic iron ore, with suitable fluxes, and when a sufficient charge of melted steel has accumulated on the hearth of the furnace it is, if requisite, mixed with some "spiegel" iron, and then run off into moulds. This method of producing steel has not yet advanced beyond the experimental stage; but it is one of great interest in many respects.

I have now completed my account of those new methods of manufacturing steel, which appear to me most important, and it would occupy too much time, besides being foreign to the present purpose, to refer to the numerous small fry of inventions relating to various minor details of this industry, further than to say that the value of many of those inventions depends upon the fate of the several methods proposed for the production of steel on a large scale, and with them they must either stand or fall.

Hitherto I have spoken of steel almost exclusively as being merely a form of malleable iron, containing only certain proportions of carbon, varying within narrow limits; but it is necessary now to observe that this is only theoretically the case. Almost all varieties of steel contain, besides carbon, certain admixtures of other substances, generally regarded as impurities, which vary greatly in amount, according to the nature of the raw material the steel is produced from. These substances are commonly silicon, sulphur, phosphorus, arsenic, &c., and they are generally considered to have much influence, according to their amount, on the quality of steel. I must confess, for my own part, that there appears to be a very great deficiency of any such satisfactory evidence in support of the opinions entertained as to the nature and extent of such influence as would be desirable in relation to a manufacture of so much national importance as the production of steel. The state of our knowledge as to the chemistry of steel and steel-making is but little, if at all, more advanced now than it was fifty years ago, when chemistry was scarcely a recognised science. For individual investigation by the chemist, iron-smelting, or the chemistry of steel making, are subjects which cannot be pursued to any great extent, owing to the nature of the operations they involve, and, in that respect, therefore, it is not surprising many questions of interest yet remain unsolved or doubtful; but it certainly does seem strange that in a country where this branch of metallurgy affects interests of such magnitude, and forms so large a source of material prosperity, there should not be greater regard paid to developing the science of the art, either by the State or by practical metallurgists.

Before concluding I must, in a few words, refer to certain characteristic features of the various methods of making steel which materially affect their economic value. It is not alone essential that any particular method should be capable of furnishing good steel, but it is of even greater importance that it should do so in such a manner as to meet modern requirements in regard to this material. Among the conditions to be considered in reference to this point the chief are the expenditure of labour and consumption of fuel requisite, the quality and quantity of the material capable of being operated on, and the quantity as well as the condition in which the products can be obtained at one time. The last point is, probably, of the first importance, for since the time that Huntsmann introduced the manufacture of cast steel, about a century ago, there has been a steadily growing demand for means of obtaining large masses of steel in a melted state. Krupp, in Westphalia, led the way towards attaining this object by the admirable organisation of his works for melting steel in crucibles. Bessemer took the next step, by introducing a method of producing almost any required quantity of melted steel direct from pig-iron, and thus saving, in many instances, the cost incidental to puddling the pig-iron, cementation of the malleable iron, and remelting of the blister steel in crucibles, at the same time affording the possibility of dealing with large masses of melted metal. Siemens has made another advance, by furnishing a means of employing worn out rails as a material for producing steel with similar advantage as regards the quantity of material capable of being dealt with in a melted state; and, lastly, Heaton claims to **have devised a method of rendering available as material for producing steel those abundant but inferior kinds of pig-iron obtained from iron ores which may, probably, in future constitute our chief source of iron and steel, though a few years ago they were regarded as mere rubbish.** Any method of steel making calculated to meet the wants of the age must, it appears, yield its product in a melted state, so that the metal may have the highest degree of homogeneity, and be free from the defects arising from interlamination of slag and foreign substances. The method which effects this result most directly will, so far, be preferable; but, at the same time, its value will be proportionate to the range of variety in raw material to which it may be applicable.

With these remarks I have now completed my attempt to place before you a brief but comprehensive review of the latest progress in steel making, and I trust you may think it worthy of being supplemented by a discussion of the several points referred to, which, as I before said, I shall regard as giving the chief value to the paper you have done me the honour to listen to.

The CHAIRMAN thought they had listened to a very interesting and instructive paper, which was calculated to give rise to some discussion between those present who might be in favour of one or other of the processes referred to. The intimate connection between the science of chemistry and the art of making steel was every day becoming more extensively recognised, and there was no doubt that the result would be that we should get still cheaper steel. The success of the Bessemer process has given a great stimulus to experiment in the iron and steel trades of this country, and that stimulus was heightened by the active competition of the Belgians and the Germans. The French were also making rapid strides in the theory of the iron and steel manufacture. Dr. Paul had laid before them a concise account of all the new processes which were at present attracting particular attention, and he would be glad, before making any further remarks, to hear the opinions of the meeting upon some of them.

Mr. CAMPIN understood Dr. Paul to have stated in his paper that pig-iron almost entirely free from phosphorus was absolutely necessary to the success of the Bessemer process, and he believed that one of the great advantages claimed for the Heaton process was that the presence of phosphorus did not so far interfere with it as to prevent the production of a good quality of steel. If this were so, he could not help thinking that the Heaton process must be an extremely valuable one.

The CHAIRMAN said that the Heaton process certainly seemed to possess considerable merit, and to have given some extraordinary results. As to the quantity of nitrate of soda used, he did not observe that it was mentioned in the paper. He would like, therefore, at the conclusion of the discussion to ask Dr. Paul as to the quantity of nitrate of soda necessary. It would be a matter of considerable interest to ascertain as nearly as they could the relative cost of manufacturing a ton of steel by the Bessemer process and by the Heaton process respectively. In the Bessemer process there is, he believed, a loss of iron to the extent of about 20 per cent., and it would be interesting to know whether the cost of the nitrate of soda used in the Heaton process was not compensated by this.

Mr. HERBERT NOYES, jun., being personally interested in the Heaton process, might state that the amount of nitrate of soda used varied from 113 lbs. upwards to the ton of steel produced. It depended entirely upon the character of the raw material they had to deal with. In a process so essentially chemical, the proportion of nitrate used would be determined by previous analysis of the materials to be operated upon. When the process is conducted upon a more scientific basis than at present they would be better able to give a definite answer to the question; but he might state that Mr. Heaton found that about 10 per cent. of nitrate to the ton of steel accomplished all that was required when ordinary brands of iron are operated upon. It was most favourable for the Heaton process to use iron with the smallest amount of carbon in it; and he thought he might say that, as a general rule, 1½ cwt. of nitrate of soda to the ton of steel made would be the largest amount necessary. The process had been carefully investigated by Mr. Williams, the chemist of Sir John Brown and Co. (Limited), and his analysis showed some remarkable results. He found that the silicon had been eliminated to a greater extent than was shown by Prof. Miller's report. This he accounted for by supposing that in the case of Dr. Miller's analysis the sample was taken from the outside of the ingot, and that there was some adhering silica.

The CHAIRMAN was glad to learn that there was such good evidence of the silicon being eliminated. He belived that the soda of the nitrate is active as well as its oxygen—the oxygen would burn away the carbon, whilst the soda might take up the phosphoric acid and silica produced. He observed, also, that carbon seemed to be at the root of everything in steel making. Steel containing 0·6 per cent. of carbon hardens enough by tempering to strike fire; when from 1 to 1·5 of carbon is present the metal acquires by tempering its maximum of hardness and tenacity; with 1·8 per cent. of carbon it is still harder, and very tenacious; it can still be worked and hammered, but cannot be welded; and, with 1·9 per cent. of carbon present, the metal is not malleable when heated.

Mr. NOYES said that as Dr. Paul had given considerable attention to the subject of steel making, he would like to ask him whether he had found nitrogen to exercise any influence, beneficial or otherwise, upon the quality of the metal?

Dr. PAUL had not. He could only say that as to the existence of nitrogen in steel, the question of its being an essential element was one which had never been decided so as to satisfy the minds of chemists. As to the bearing of that question upon the Heaton process, there was the probability that if nitrogen be an essential element, they might explain some circumstances which now appear remarkable. The action of the nitrate of soda was considered to be simply that of supplying a certain amount of oxygen, by which the carbon was oxidised into carbonic acid as in the puddling-furnace, going off in the form of gas; the silicon was oxidised into silicic acid to assist in forming slag; whilst the phosphorus, sulphur, and arsenic were acted upon in a similar manner, and converted into their higher oxides—all being oxidised by the oxygen of the nitrate of soda; and the sodium was there to sieze upon the acids formed. According to Mr. Heaton's views, the proportion of nitrate of soda used will be in proportion to the necessity for separating phosphorous; if we can leave in more phosphorus we shall want less nitrate of soda. This accords with Prof. Miller's theory of the Heaton process. He (Dr. Paul) would have supposed that 20 or 25 per cent. of nitrate of soda would have been necessary for treating the iron ores of Northamptonshire, but Mr. Heaton had given them the statement that 10 per cent. only had been used, and they had had good steel.

The CHAIRMAN said that although Dr. Paul had replied to Mr. Noyes' enquiry as to the influence of nitrogen upon the quality of steel, he would observe that the subject was one which had been more recently studied upon the other side of the Channel than on this. Prof. Frémy had once energetically contended that nitrogen was an essential element in steel, but the subject had now been fully discussed, and such extremely small proportions of nitrogen had been found, and these proportions were so inconstant, that the question now be considered to have been decided against him—in fact, more nitrogen exists in pig-iron than in steel. The presence of nitrogen was formerly supposed to be necessary during the process of steel making, because it had been found that certain cyanides and other nitrogenous substances easily operated the transformation of wrought-iron into steel. He (the Chairman) explained this by the fact that the carbon of the cyanides was in a very suitable condition for cementing wrought-iron. He reminded the meeting that hard burnt carbon would not produce cementation. It was, therefore, the carbon of the cyanides alone that was active, and nitrogen evidently had nothing to do in the manufacture of steel.

Mr. YATES observed that the members of the Inventors' Institute were rather thinkers than talkers, and that the various new processes had been so thoroughly described that little remained to be said with which they were not familiar. He must say that the character of the slag was that which struck him most in connection with the Heaton process.

Mr. G. F. ANSELL enquired whether it would not be an advantage in the Heaton process to dry the nitrate of soda before using it? It

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* Messrs. Samuelson have recently commenced operations with these furnaces.

seemed to him that much of the vapour described by Dr. Miller was vapour of water. The nitrate was well known to be solid or semi-solid in the commercial state, and it occurred to him that if the nitrate were first dried the product would be obtained in a better condition.——Dr. PAUL would imagine that the nitrate of soda would be dried before it was used, as it was well known to contain a large quantity of hygroscopic moisture.

Mr. NOYES said that the nitrate of soda was not dried previously to being used in the Heaton process; it was kept in a damp cellar, and Mr. Heaton believed that it acted better for being somewhat moist. With regard to obtaining the iron in a fluid condition, it was found that very fluid iron was obtained when silicon was present. In the French experiments to which he had referred, one of the irons rich in silicon was obtained in a very fluid condition.

Dr. PAUL said that as to silicon influencing the fluidity of the metal, there was no doubt that silicon had some influence, but the extent was not thoroughly ascertained. In the carrying out of the Bessemer process, on operating upon a certain kind of iron, honeycombed ingots were produced, and by the introduction of silicuretted iron this honeycombing was prevented.

Mr. NOYES thought the honeycombing was prevented by the introduction of a certain compound into the ingot moulds. This composition had the appearance of red lead, and he would be very glad to know what it really consisted of.

Upon the proposition of Mr. CAMPIN, a vote of thanks to Dr. Paul was carried by acclamation, and, having been duly acknowledged, the CHAIRMAN announced that at the next meeting a paper would be read by Mr. Desmond Fitzgerald, "On Electrolytic Insulation."

THE MINERAL RESOURCES OF NOVA SCOTIA.

Although entitled to a place amongst the richest of the dependencies of Great Britain, as far as regards mineral wealth, Nova Scotia has hitherto been much neglected by English capitalists, and that there may be no excuse for the assertion that this neglect arises from difficulty in obtainable reliable information concerning the resources, Prof. HENRY HOW, of King's College, Windsor, has just completed a report to the Provincial Government on the Mineralogy of Nova Scotia, in which such an abundance of facts, ascertained from careful investigation, is given that the effect must be to attract capital from England for the development of the Nova Scotian mines. The first place is, of course, given to coal, the mineral which of all minerals plays the most important part in connection with the industrial development of a country, and in this Nova Scotia has long been known to be especially favoured. It appears that the abrogation of the reciprocity treaty with the United States produced a far less unfavourable result than was anticipated. The proprietors of collieries have sought new markets, and the result had been so favourable that, although the returns showed a decrease, not only had additional mines been opened, but preparations were being made at others for a considerable extension of the powers of production. The coal of Nova Scotia is bituminous, or soft; no anthracite or hard coal has yet been met with. There are also very rich oil coals, distinguished from common coals by their composition and property of yielding oil on careful distillation, and more resembling Cannel coal. With regard to the evaporative power, it appears to be equal to that of Newcastle coal—8·37; the figures for other British coals being—Welsh, 9·05; Lancashire, 7·94; Scotch, 7·70; and Derbyshire, 7·58. The Acadia seam is 20 ft. in thickness, and is described as one of the finest seams of coal in the world, from the peculiar character of its position and construction. With the exception of the fire-clay parting of 3 in. thickness, there is not the least interstratification of foreign matter or impurity of any kind, and the parting is of great importance to the miner, because it enables him to hole in it instead of cutting the hard coal. The Acadia coal has acquired so high a reputation as a superior household coal that it was found necessary to issue certificates with each load sold as a protective measure.

Up to the present time no attempt has been made to manufacture oil from shale, except in the case of that accompanying the Fraser oil coal. Yet the deposits of shale in Antigonish county are very favourably spoken of by Mr. CAMPBELL, who states that the bituminous beds appear to be divided into two groups, the lower of which seems to be about 70 or 80 ft. in thickness, 20 ft. of which may be regarded as good oil shale, including 5 feet in curly Cannel rich in oil. The upper band, which lies in immediate contact with the limestone, cannot be much short of 150 ft. in vertical thickness of strata, containing a large percentage of oil. Of this great bed of oil-batt, about 30 feet will, in all probability, yield from 20 to 25 gallons to the ton. The Five-foot seam of curly Cannel will yield at least 40 gallons of crude oil to the ton, and the 15 ft. of the best section of the oil-batt will yield at least 20 gallons to the ton, and taking this as worth 1s. per gallon at the shipping port, there are, in all, upwards of 70,000,000*l.* worth of oil, which can be obtained from 20 ft. in thickness of strata, underlying 2000 acres of land—out of 18,000—comprising a basin underlaid by at least 50 feet in thickness of beds rich in oil. Liquid bitumen, petroleum, or mineral oil is reported to have been found in more localities than one, and a more interesting discovery of solid bitumen was made by Mr. BARNES in the neighbourhood of Grand Anse, Inverness county; this bitumen resembles the albertite of New Brunswick. Extensive peat bogs are found in the province; the largest, perhaps, are the savannahs in different parts of Shelburne county, and the carribou bog, near Aylesford, King's county. They are especially frequent in the rocky country of the Atlantic coast, near the gold districts of Tangier and Sherbrooke. Mr. CAMPBELL mentions the existence of considerable tracts of peat on the table-lands in the Cape North district of Inverness and Victoria counties, Cape Breton. No examination has been made of the depth and quality of the peat in these deposits, but the subject is well worth attention, as peat is now extensively used as a fuel in generating steam, and in smelting and working iron, especially in the case of iron-sand, which is met with on the Atlantic coast of the province.

Gold was found in Nova Scotia about 100 years ago; it is found in the metamorphic district forming the southern half of the province, in the altered rocks of different parts of the northern and eastern portions of Nova Scotia and Cape Breton, and in the detrital deposits derived from these rocks respectively, met with in the lower carboniferous formations; it is said to occur, also, in the trap of the new red sandstone, and is often found in superficial alluvial deposits. The gold exists to some extent in the quartzite and slates, but generally occurs in leads, consisting chiefly of quartz running through the quartzite, and less frequently through the slates. The leads contain more or less mispickel, galena, blende, iron pyrites, copper pyrites, and peroxide of iron; argentiferous copper, sulphide, molybdenum, and, as at Oldham, native copper are occasionally observed. As a general rule, those leads only are found to be productive which are conformable with the containing rocks, and are, therefore, held to be beds as distinguished from veins. Notable exceptions occur at the Ovens, and at Oldham, where very rich cross veins are found. In gold mining the success may be considered good, both in the increase of gold obtained and the average rate per ton of quartz crushed, whilst the average remuneration for each man, counting 313 days in the year, and the gold at $18·50 per oz., is $2·44—a result, it is believed, without parallel in any country. The progress in the yield of gold has been steady, and a large increase may be expected in the working of the poorer mines. Leads are now made to pay which at first could not have been worked without loss, and leads now deemed worthless will, no doubt, owing to the increased experience in mining and treating the ores, be found remunerative.

Native silver is found abundantly disseminated through the drift of the Mackenzie River in small grains and nuggets. The sources from which this stream derived the silver rolled in its drift are, in Mr. CAMPBELL's opinion, first from veins of a beautiful variety of spar, closely resembling meerschaum, that abound in some parts of the district; some of the veins contain native silver, embedded in strings and nests of a softish grey substance of earthy texture, much resembling the carbonate of that metal. The other source he believes to be the general surface of glacial drift along its banks and tributaries. Silver has also been found in manganese ores, coal, and native copper. Silver ores occur at Watchabuck, Cape Breton—a sample assayed by Dr. HAYES, of Boston, gave at the rate of 18 ozs. 9 dwts. 3 grs. of gold and 97 ozs. 10 dwts. 4 grs. of silver to the ton of 2000 lbs. Argentiferous galena has been found at Little Bras d'or. A small specimen of antimony was given to Prof. How as coming from within a few miles of Halifax. The existence of the rich antimony deposits, consisting of the sulphide with occasionally a notable amount of native metal in the lower silurian rocks of New Brunswick, which are now being extensively worked, renders this indication of importance. Mercury and its sulphide, cinnabar, are said to have been found at Gay's River, Colchester county. Molybdenum, arsenic, cobalt, nickel, and bismuth have also been found.

Copper is found at several localities on the shores of the Bay of Fundy and of Minas Basin; the metal is found in rounded and flattened pieces embedded in the trap, and in similar forms in the shingle at its base; a specimen of 15 lbs. weight is reported to be obtained on the west side of the Cape. Ores of copper are found at many localities, and are occasionally very rich; in 1867 operations were commenced on a vein at Polson's Lake. Copper ores are also worked at Tatamagouche, Colchester county; Cheticamp, Cape Breton; East River of Pictou; Indian Point, Five Islands, Cumberland; and in other localities. The only ore of lead found in the province is galena, which occurs in many localities, but only one of these has been thought sufficiently rich to encourage mining operations. The only ore of zinc yet met with is the sulphuret, but the quantity has not been found to be of mining importance. The largest pieces were from Mount Uniacke. Tinstone has been found by Mr. BARNES in a sand composed of quartz and decomposed felspar in Tangier, and by Mr. CAMPBELL at Shelburne. Prof. HOW gives the analysis of a native alloy of copper, zinc, and tin—a substance of metallic appearance, and somewhat tin-like colour—on fresh surfaces, sent to him some years since; the composition (copper, 57·29; zinc, 20·54; tin, 19·94; lead, 2·39; and iron, 0·08=100·24) found being so entirely unlike that of any known mineral, and no matrix being furnished with the specimens examined by him, mineralogists have refused to believe in the substance being a mineral; but, as Prof. HOW observes, there is also no artificial alloy having anything like the same proportions of ingredients. Plumbago suitable for crucibles, &c., and sulphur are also referred to as existing in the province.

The province is abundantly supplied with a variety of such iron ores as are employed in smelting; a few only of their localities have been the scenes of mining operations. The one smelting-works now in operation produces a very fine quality of charcoal iron—the high reputation of the Acadian charcoal iron is well known to the readers of the Journal. The ores of manganese, gypsum, anhydrite, &c., are in turn referred to, and Prof. HOW gives an admirable account of the resources of the province for the manufacture of salt. It would appear, too, that Nova Scotia is not without good building stones, and minerals adapted for the manufacture of jewellery. The work is highly interesting throughout, and the only conclusion that can be drawn from its careful perusal is that Nova Scotia presents far greater attractions to the capitalist than many countries to which they have given more substantial support.

THE ORIGIN OF VALLEY GRAVELS.—That Science is far more indebted for the accuracy which secures her respect to the practical worker in the field than to the professional scientists is daily becoming more generally recognised, and the excellent and exhaustive paper "On Quaternary Gravels," by Mr. A. TYLOR, F.G.S., is certainly not calculated to lessen the extension of this opinion. The paper, which was read before the Geological Society of London, has just been printed as a separate pamphlet, which will be read with much interest by a very large number of working geologists. As an amateur, with ample means and opportunities for thoroughly investigating any geological question he may take in hand, and one who, moreover, has an unlimited amount of energy and perseverance, Mr. Tylor has succeeded in collecting a mass of valuable information which will add materially to our geological knowledge, whilst he has shown by the admirable manner in which he has framed his arguments upon the results of his researches, that he possesses an acquaintance with the purely scientific principles of the science of geology, of which many who enjoy a high professional reputation in connection with it might fairly envy him. Neither trouble nor expense has been spared to make the paper a complete treatise upon the subject—it is enriched with well-engraved sections observed in various parts of the country, and key-maps upon an ample scale. It is understood that the reprint is for private circulation only.

BRAZIL AND THE RIVER PLATE.—That Brazil is destined at no distant period to become one of the most attractive fields for the employment of British capital is an opinion which almost daily exhibits itself; the increased facilities offered for industrial enterprise by the development of undertakings for improving the means of communication cannot be overlooked; and as, taken on the whole, the result secured by capitalists who have connected themselves with Brazil has not been unsatisfactory—which is more than can be said with regard to similar early efforts elsewhere—that country is certainly entitled to favourable consideration, more especially as whatever obstacles formerly existed to prevent commercial success are gradually being removed. Looking to increased intercourse between England and Brazil, which these circumstances indicate, and knowing that capitalists are generally anxious to learn something of the countries in which their money is embarked, an interesting volume by Mr. WILLIAM HADFIELD, entitled "Brazil and the River Plate in 1868," showing the progress of those countries during the past 15 years, has just been issued (through Messrs. Bates, Hendy, and Co., of Old Jewry). Since Mr. Hadfield's former visit, in 1853, a large amount of English capital has been invested in various enterprises connected with Brazil and the River Plate, and particularly for the contruction of railways, the formation of banks, and the promotion of steam navigation on the great rivers communicating with the interior, and in connection with many of these undertakings large gains have been secured, showing that those regions present a profitable and wide field for the further employment of surplus capital. As the success or failure of industrial enterprise almost invariably depends upon the facilities which exist for the transport of produce, Mr. Hadfield's account of the railways and means of water communication is particularly interesting, and as the whole of the information is given in the form of a traveller's narrative, it is very readable and attractive. After describing the cities of Monte Video and Rio de Janeiro, accounts are given of the war in Paraguay, the San Paulo Railway, the Don Pedro Segundo Railway, the Central Argentine Railway, the Western Railway of Buenos Ayres, Steam Navigation on La Plata, the Railways of the River Plate and of Brazil treated generally, and of other public matters, a knowledge of which is essential to the intending investor, who desires to investigate his chances of success before risking his capital. With regard to the mineral resources of Brazil, it is probable that, much as has been produced from Brazilian mines with the aid of English capital, but few fully appreciate the vast extent to which the country has been favoured by Nature. There is scarcely one of the many provinces of Brazil in which valuable mines do not occupy an important position in the list of commercial resources. Excluding Para and Piauhy, every province has mines of one kind or other, each possessing some special attraction. The gold mines of Minas Geraes are well known to British capitalists, and this same province also produces diamonds and other precious stones, and iron. Similar mineral riches are found in Goyaz, in Espirito Santo, and in Parana. In Matto Grosso they have gold, diamond, iron, and copper mines; in Amazonas, silver mines and marble quarries; in Rio Grando do Norte, gold and silver mines; and in Parahyba, gold mines, iron ores, and saltpetre. Nor is it only in the precious and other metals and precious stones that Brazil is wealthy: that most important of all mineral productions, considered in a commercial sense, coal is found in several of her provinces, and when increased energy and capital shall have been brought to bear upon them will doubtless do much toward rendering the empire independent of foreign supplies, at least to a very considerable extent. The province of Santa Catharina possesses coal mines, and a great quantity of iron ores; in San Pedro do Rio Grande do Sul, there are coal mines and other minerals; in San Paulo, iron ore, copper, silver, gold, precious stones, and coal; in Rio de Janeiro, iron mines, and china and porcelain clays; in Bahia, rich gold, diamond, silver, iron, copper, coal, and marble mines; in Alagoas, anthracite and bituminous schist; in Maranhao, gold mines; in Ceara, mines of gold, silver, lead, iron, antimony, amianthus, coal, marble, nitron, salines, &c.; in Sergipe, gold and diamond mines, marble, nitrates, iron, slates, and salines; and in Pernambuco there are mines, although hitherto they have not been explored. The book is illustrated with several well executed engravings, and is altogether worthy of careful perusal.

UNWISE COLONIAL POLICY.—The able work by Mr. C. W. DILKE, M.P., entitled "Greater Britain," boldly exposes the folly of the policy still pursued by this country, burdened with pauperism as it is, in paying millions a year for troops to guard rich colonists who will not contribute any proportionate share themselves, who would not fight for the Mother Country in time of war, and who now laugh at her expense. Says Mr. Dilke, "Canada is in all ways the most flagrant case. She draws from us some 3,000,000*l.* annually for her defence. She makes no contribution towards the cost; she relies mainly on us to defend a frontier of 4000 miles, and she excludes our goods by prohibitive duties at her ports." (About 30 per cent. duty on British goods). As to the Australian colonies, we spend millions merely to amuse them with military reviews. Mr. Dilke adds—"The fear of conquest of the Australian colonies if we left them to themselves is, on the face of it, ridiculous." Neither France nor Britain could conquer the nearer American colonies, when peopled by only one million and a half. In case of war Britain would either withdraw her colonial troops, or they would be worse than useless, as, indeed, they are at present. Mr. Dilke writes—"The present system weakens us and them—us, by taxes and by the withdrawal of our men and ships; the colonies, by preventing the development of that self-reliance which is requisite to form a nation's greatness." The members of the new Parliament are bound, in duty to their constituents, to resist the further continuance of these costly and useless colonial armaments.

"QUARTERLY JOURNAL OF SCIENCE."—The April number of this magazine contains original articles on the Malay Archipelago; the Projected Mersey Tunnel and Railway (from Liverpool to Birkenhead), by Sir Charles Fox; Vesuvius; the Artificial Production of Ice and Cold, by Dr. B. H. Paul; on Some Recent Spectroscopic Researches, by Mr. W. Huggins, F.R.S.; and on the Future Water Supply of London, by Prof. C. W. Heaton. The Chronicles of Science are of the usual attractive and interesting character. The several papers are amply illustrated with woodcuts and lithographs.

Meetings of Public Companies.

FORTUNA COMPANY.

A general meeting of shareholders will be held at the company's offices, Queen-street-place, on Thursday next, when the subjoined report of the directors will be submitted:—

The directors have great satisfaction in being able to present a favourable report to the shareholders on the present occasion, and at the same time to assure them that, notwithstanding the revolution which has taken place in Spain, the company's property has neither been molested nor injured in the slightest degree. The mines continue to be worked with all possible economy, and at the same time are maintained in a state of great efficiency. The new pumping engine recently erected at Salidos has been completed, and is doing excellent duty; and a small rotary engine, for proving some unwrought ground, has also been provided. In September last the directors stated that they had it in contemplation to reduce the monthly extraction of ore to some extent, if they found that the working expenses could be proportionately diminished, believing that more profit might probably be made under such circumstances. This system has been tried during a portion of the past half-year, and with very beneficial results, as the raisings have been diminished by 172 tons, and notwithstanding this an increase of profit is shown. There is, however, the further advantage to be noted, that by thus lessening the raisings the ore in reserve has not been decreased; it remains at 9125 tons. The exploratory works have been actively prosecuted, both at the Canada Incosa and Salidos Mines, and with encouraging results. Both mines are productive at their deepest point, and the appearance for the future is very satisfactory. The smelting operations, which continue to be conducted at the mines under the superintendence of Mr. Tonkin, have yielded a good produce at a low rate of cost. Operations at these works have not ceased during any portion of the half-year. The construction of the projected new cart-road from the mines to Baeza station, referred to in the last general report, has been temporarily delayed, in consequence of the disturbed state of the country, but the Spanish Government have lately invited tenders for a contract to make the road. With the exception of an increase in the rate of coal carriage there has been no alteration of importance in the transport charges since September last. There was some confusion in the carriage arrangements during the height of the revolution in Spain; this, however, soon ceased, and did not occasion absolute loss, but merely delay. The second instalment, of 3750*l.*, was paid to the debenture holders on the 19th ult., and hence the debenture debt now stands at 7500*l.*, one-half of which is payable on Feb. 19, 1870, and the remainder on Feb. 19, 1871. Towards this sum the directors have put aside 3214*l.* 5s. 8d., leaving 4285*l.* 14s. 4d. still to be provided. The lead market has become much firmer and healthier in tone during the past few months; 19*l.* per ton is now the price of Spanish lead, at which a sale of this company's lead has recently been made. This is an improvement of 15s. per ton on the price which ruled six months ago. The audited accounts show that the profit on the half-year has amounted to 5133*l.* 10s. 4d.; after making the usual provision for the redemption of the debenture debt, and for the interest on same, there is a balance to the credit of the profit and loss account of 4332*l.* 1s. 2d.—Out of this amount a dividend of 3s. per share has been declared, payable on April 10 next, 3750*l.*; and it is proposed to write off as depreciation from the plant account 500*l.*=4250*l.*: leaving a balance to carry forward to the next account of 82*l.* 1s. 2d. In regard to the half-year which has now been entered upon, the directors anticipate that a good profit will again be made, and they have great hope that the next dividend will be at the same rate as the present one. The directors who retire by rotation are Messrs. William Cox, Robert Palgrave, and Richard Taylor; they are all eligible, and offer themselves for re-election.

ALAMILLOS COMPANY.

A general meeting of shareholders will be held at the company's offices, Queen-street-place, on Thursday next, when the subjoined report of the directors will be submitted:—

The accounts which are appended to this report will furnish you with an accurate statement of the financial position of the company on Dec. 31 last, both as regards its assets and liabilities. They will also show that the profit on the half-year has amounted to 4529*l.* 6s. 9d., which is a satisfactory increase on the previous six months—indeed, it is the largest profit yet made. The mines have now been yielding profits for the past two years, and the following figures, extracted from the published accounts, will show the gradual progress made during that period:—The profit in the six months to June 30, 1867, was 2009*l.* 19s. 9d.; in the six months to Dec. 31, 1867, it was 3006*l.* 17s. 9d.; in the six months to June 30, 1868, it was 3986*l.* 8s. 2d.; and in the six months to Dec. 31, 1868, it was 4529*l.* 6s. 9d. Out of the balance now standing to the credit of the profit and loss account, the directors have declared a dividend of 2s. per share, which will absorb 3500*l.*, and they propose to write off a further sum of 500*l.* from the account, "outlay on mine works."—The Mines: A good extraction of ore has continued to be maintained, the yield being 1600 tons, or an average of 266 tons per month. The new ground opened has varied in productiveness, and at some points has not proved satisfactory; but it will be seen by the mining agents' report that the reserves have not been diminished—they still stand at 2500 tons. Mr. Tonkin is of opinion that good ore ground will be opened up during the present six months in various sections of the mines, but especially between San Victor and San Jose shafts, where there are parallel lodes of great promise. The mining expenditure continues to be kept at the lowest rate consistent with efficient working, and any machinery that is required from time to time is at once charged to revenue account..—Smelting Operations: During the six months 1448 tons of lead ore have been smelted, assaying, on an average, 77 per cent. Consequent on sundry stoppages, the produce has suffered to some extent, but, on the whole, the work done has been good. Some reduction in the smelting cost has been effected, as will be seen by Mr. Shaw's report. At the last general meeting it was arranged that the rate to be paid to the Linares Company for smelting at their works, including management charges, interest on capital, wear and tear, &c., should be submitted to the arbitration of Messrs. F. J. Bramwell and Henry Thomas. The Linares Company concurred in this, and the matter having been fully laid before the arbitrators, they awarded that the charge should still continue at 6s. 8d per ton.—Carriage: A trifling reduction of 7½d. per ton of lead has been made by the Cordova and Seville Railway Company, but the directors have been unable to obtain any reduction from the Madrid Railway Company in the heavy rate charged between Linares and Cordova. The disturbed state of Spain caused some irregularity in the traffic at one period of the half-year; this, however, was of short duration, and the company's produce has since been forwarded with punctuality.—Lead Market: The new year has given a great impetus to the lead market; both the exports and the home consumption have been larger, while the stocks held by manufacturers are smaller than usual. The result of this has been that the price of Spanish lead has risen from 18*l.* 7s. 6d. to 19*l.* per ton, and a further advance may be expected. The directors have only further to congratulate the shareholders upon the present position of the company's affairs, and to assure them that no efforts will be spared to maintain a continuance of its prosperity. Messrs. Robert Henty and Charles Morris are the directors who retire by rotation at this meeting; they are both eligible, and offer themselves for re-election.

LINARES LEAD MINING COMPANY.

A general meeting of shareholders will be held at the company's offices, Queen-street-place, on Thursday next, when the subjoined report of the directors will be submitted:—

You will have received notice that a dividend of 3s. 4d. per share, free of income tax, has again been declared. In the report of September last, the prospect of this dividend was held out to you, and the directors have the satisfaction of stating that they are enabled to pay it without in any way hampering the finances of the company, and still leave 3022*l.* 6s. 11d. to the credit of profit and loss account. The profit made during the past half-year has amounted to 2263*l.* 4s. 4d.; this is not so large as was yielded to June 30 last, and has arisen from various causes, but mainly from the ore smelted having been of a somewhat inferior quality, and from interruptions caused by the revolution in Spain.—The Mines: 1795 tons of lead ore were raised during the last half-year; this extraction, averaging 299 tons per month, has been maintained without lessening the estimated quantities of ore in reserve, which have again been returned at 800 tons. The explorations at Pozo Ancho and Warne's Mines continue to be attended with unsatisfactory results, but there has been compensation for this in the increased productiveness of the San Francisco lode—a section of the mine scarcely worked until within the past two years, but which is now yielding a good return of ore. At the Quinientos Mine the appearance of the underground workings has varied very much during the last six months; some points have fallen off, whilst others have greatly improved. At the San Carlos shaft, which is 256 fathoms to the east of the engine-shaft, there is an excellent lode in the bottom, worth 3 tons per fathom, and every effort is being made to open up that section of the mine. The lode is one of great strength, and will be proved in depth as speedily as possible. An improvement has just been reported in the lodes at Taylor's and Cox's shafts. The expenditure on this mine during the past half-year has amounted to 2349*l.* 13s. 1d. The accounts will show that against this cost 120 tons of ore have been placed, of the estimated value of 1005*l.* Much of this ore was raised during the half-year, and there remains 100 tons of discovered ore in reserve. The total net expenditure on this mine from the commencement, irrespective of the purchase money, now amounts to 6595*l.* 19s. 5d., which sum has been entirely provided out of capital.—Cordova Smelting-Works: The hope expressed in the last report, that the cost of smelting would be reduced, has been verified, and this in spite of the drawbacks and hindrances caused by the revolution in Spain. The assay of the ore, as before mentioned, has been lower, and this has been attended with a corresponding reduction in the produce from the furnaces. The ore lately received at Cordova has been of a better quality, and should this continue, it will benefit the accounts of the present six months. The ore raised by the Alamillos Company is still smelted by this company at a charge of 6s. 8d. per ton, for management, interest on capital, wear and tear of works, &c.—the award of the arbitrators, appointed in October last by the two companies, having been that the charge should continue at that rate.—Transport: The frequent conveyance of Spanish troops on the railways in the neighbourhood of Cordova has at times impeded the ordinary goods traffic, and has rendered the conveyance of the company's ore, lead, and coal uncertain and irregular. At present these impediments are mitigated, and the produce is brought to market with great dispatch.—Lead Market: The price of Spanish lead during a great part of the past half-year was 18*l.* 7s. 6d. per ton, but in the month of January an improved

demand sprang up, and prices have since gradually improved. A sale has just been effected at 19l. per ton. Taking into account the improved state of the lead market, and the economy with which the mines are worked, and the smelting operations conducted, the directors believe that the prospects of the company for the present year are good, and they have every confidence that they will again be able to declare a dividend in September next. After the present year much will depend on the productiveness of the Quinientos Mine. The directors who go out of office by rotation are Messrs. William Cox, John Phillipps Judd, and Robert Henty. They are all eligible, and offer themselves for re-election.

LAGUNA SILVER MINING COMPANY.

The sixth ordinary general meeting will be held on Wednesday. The report of the directors, to be submitted, states that the total amount expended upon the mine from the commencement up to Dec. 31 was 8010l., of which 3306l. was contributed by ores extracted in the shallow workings above the 75 vara level. In order to satisfy the shareholders as to the value of their property, and to give them every information upon which to decide on their future course regarding it, the directors have had the mine carefully examined and reported upon by Mr. John P. Sewell, of Real del Monte, and in addition to his report they append the following extract from a private letter written by him to one of the early shareholders, dated Nov. 22, 1868:—"By the present mail I send you a long and I consider a very satisfactory report on the Laguna, by which you will see that my opinion is more confirmed than ever that you have a very valuable property." And after stating his strong opinion as to the necessity of a more energetic opening out of certain portions of the mine, Mr. Sewell proceeds to say:—"By following these views you may hope ere long to make a splendid affair of Laguna. The shaft looks most promising, and it is absurd to work so little, as the work done costs you very heavily, because the office expenses and management are just the same as if you were doing double the work. At the same time you must not grumble if the expenses increase somewhat, but you may expect by this means to arrive at a favourable result. To show you that I back my opinion, I have purchased from Mr. Rule a half barra—say, 1-48th of the mine. I think you should agree to an expenditure of $200 to $250 per week as the lowest figure at which the mine can be worked with a fair activity and progress, combined with economy. I think altogether you will be satisfied with my report and ideas, as I have given great attention and consideration to every part of the question, and trust it will be satisfactory to yourself and the shareholders, and that it will elicit a vote of satisfaction." The grand point remaining for consideration is the best mode of raising funds necessary for a more complete development of the mine. After giving the subject their full consideration, the directors have come to the conclusion of simply placing the question of additional funds before the shareholders, and inviting from them suggestions in general meeting as to the most desirable mode of meeting the present emergency and proceeding for the requirements of the mine. Looking at the comparatively small outlay already made, and the measure of success which attended the company's earlier operations, and considering also the many favourable and encouraging features both as regards natural position and general reputation of the Laguna Mine, the directors cannot but feel the property to be well deserving of a more energetic system of working than has been possible with the restricted funds hitherto available for that purpose.

[For remainder of Meetings see to-day's Journal.]

FOREIGN MINING AND METALLURGY.

The amount of the exports of coal from Belgium in 1868 amounted to 3,759,000 tons, against 3,564,000 tons in 1867, and 3,972,000 tons in 1866. In these totals the exports to France figured for 3,612,000 tons in 1868, as compared with 3,442,000 tons in 1867, and 3,819,000 tons in 1866. These results are more favourable than those of 1867, but it will be remarked that they are sensibly the same as in 1866. The exports of coke last year from Belgium amounted to 539,966 tons, as compared with 516,898 tons in 1867, and 547,504 tons in 1866. The exports of coke, like those of coal, thus attained their maximum in 1866. The imports of coal into Belgium declined to a rather remarkable extent last year, as compared with 1867, having fallen in 1868 to 421,219 tons, against 247,743 tons in 1867, showing that Belgian coal remained during 1868 at a price which rendered the competition of foreign coal extremely difficult. Some sales have enabled the depôts at the great consuming centres to run off a portion of their supplies; these sales, encouraged by a rather rigorous temperature, have exerted only a slight influence, however, on the Belgian markets. The considerable number of deliveries in course of being made and the important stocks on hand in the various Belgian basins are not facts calculated to improve the state of affairs; at the same time extractors are doing their utmost to maintain prices by reducing the extraction. The exports of minerals from Belgium show a sensible falling off last year, having amounted in 1868 to only 136,067 tons, as compared with 152,227 tons in 1867, and 157,695 tons in 1866. Several of the Belgian mineral beds appear to be exhausted, and those which remain in working are far from furnishing the quantity of minerals required for supplying the blast-furnaces. The amount of the imports of foreign minerals indicates the continually increasing importance of this deficit. Thus while the imports of minerals into Belgium amounted to only 307,780 tons in 1866, they rose in 1867 to 322,891 tons, and in 1868 to 396,282 tons. The exports of rough pig from Belgium showed a rather sensible increase last year as compared with 1867, having risen to 16,527 tons last year, against 11,002 tons in 1867, or 5525 tons more. The imports of rough pig into Belgium declined last year to 44,130 tons; in 1867 they reached a total of 55,384 tons, while in 1866 they only amounted to 32,308 tons. The competition of English pig with Belgian pig in Belgium thus appears to have lost something of its importance last year. The exports of rolled iron from Belgium increased to 70,616 tons last year, against 54,963 tons in 1867. There was, on the other hand, a diminution of more than 10,000 tons in the exports of rails from Belgium last year as compared with 1867, the exports having amounted to 70,550 tons, against 80,875 tons in 1867, and 65,549 tons in 1866. The decline occurred wholly in the diminished exports to Russia, which were 45,340 tons last year, against 67,695 tons in 1867, and 32,510 tons in 1866. The exports of plates from Belgium showed some progress last year, having been 14,115 tons, as compared with 12,591 tons in 1867; but last year's total was, however, inferior to that for 1866, which was 16,885 tons. The whole of the exports of rolled iron, rails, plates, &c., from Belgium amounted to 189,802 tons in 1868, against 183,460 tons in 1867, and 175,280 tons in 1866, thus showing, upon the whole, a constant progress during the last three years. It may be remarked, however, that the exports of all descriptions of Belgian iron to France declined in 1868 to 38,466 tons, against 45,852 tons in 1867, and 54,228 tons in 1866. This apparent diminution in the demand for Belgian iron in France is worthy of notice, as France has hitherto been one of the most important outlets for Belgian metallurgical products. The state of the Belgian iron market has not varied materially during the last few days. The rolling-mills continue well provided with work, and the blast-furnaces have little stock on hand, and run off their daily production with ease. Charcoal-made pig is quoted at Charleroi at 6l. 4s. per ton. Some orders for large plates have been concluded on foreign account, and there has been greater firmness in prices. The Jemmappes rolling-mill has been definitively sold to one of the creditors—the banking house of Sirault, of Mons—for 5040l. There are rumours as to the intended extension of some of the Belgian works, and among others of those of M. de Dorlodot, of Châtelineau, and the Victor Gillieaux Company; the intention is attributed to the latter company of establishing a rolling-mill for merchants' iron by the side of an existing rolling-mill for plates. A Belgian industrial recently obtained an order for ten locomotives, and entertained some hope and expectation that he would be able to extend the affair; this hope has, however, not been realised, the other locomotives (55 in number) having been ordered from a French house.

The state of the French iron trade is considered to have somewhat improved of late. A rise was recently decided on by the forges of the North of France; the present price for merchants' iron is 8l. per ton. A considerable amount of activity is expected to prevail in some departments of French commercial enterprise during the ensuing summer; at Paris, for instance, the building trade is assured full work. No important change has occurred at St. Dizier; an order for engine and plant for the Transcontinental, Memphis, and Pacific Railroad is stated to have been secured by works in this district. This is the first time that French works have concluded business direct on American account, and without the intermediate agency of English firms. The same piece of good fortune occurred two years ago to Belgium, but it remained an isolated fact; it is to be hoped that it will be the same with the order just obtained by the Maubeuge forges, and by the house of Koechlin. Further, it may be remarked that the contract is to be adjusted in a pecuniary sense—that is, the work is to be paid for—in bonds, if we are rightly informed. A fresh contract for 55 locomotives has been secured on Russian account by the Creusot Works. A Russian contract for trucks went to M. Klett, of Nuremberg. The report for 1868 of the directors of the General Company for Promoting the Development of Commerce and Industry in France states that the Mokta-el-Hadid Magnetic Iron Minerals Company, founded under its patronage, has not ceased to make progress. The report of the directors of the General Company adds:—"The reputation of the Mokta minerals has no longer to be made, but it is a recognised fact that they are indispensable to the production of pig of special quality, and the importance of the part which they seem destined to play in metallurgical industry increases with the development which new processes for the manufacture of steel are now assuming. The sale of the Mokta-el-Hadid minerals amounted in 1867 to 146,000 tons, while in 1868 it was 180,000 tons. In 1869, according to the contracts entered into, it will be more than 200,000 tons." The directors hope that favourable results will be attained in connection with the Rhône Mines and Foundries Company, as the works and mines enjoy the advantages of a good situation.

At Havre 71l. 10s. has been paid for Chilian copper in bars, to be delivered at the close of March. The latest advices mention a sale of 72l. per ton, Paris conditions, with deliveries at the close of April, and 71l. 12s. per ton for deliveries in the second half of the same month. At Paris there have been no changes in prices; the article remains in little demand. At Marseilles Toka has made 68l.; Spanish, 70l.; refined Chilian and Peruvian, 76l.; rolled red copper for sheathing, 84l.; and yellow ditto, 78l. per ton. The German markets have been feeble, like all the others. At Rotterdam there has been scarcely any change worth mentioning in copper. Tin has been well held at Paris and Havre. At Paris, Straits has made 134l. to 136l. per ton, Banca 136l. to 138l. per ton, and English 128l. per ton. English tin has been held at Marseilles at 120l. per ton. The German tin markets have hardened rather considerably. At Rotterdam the impression produced by the public sales of April 1 (50,000 ingots of Banca and Billiton) has caused tin to show some advance. For Banca 81 fls. has been paid for immediate delivery, and 82 fls. for Banca, to be delivered on the terms of the auction. Billiton has brought 80 fls. on the spot, and 80½ fls. for lots under sail, and likely to arrive in a short time. As regards the general position of the article, it may be remarked that the stocks now on hand are much less than those existing at the corresponding period of last year. The official statements show a stock in Holland of 219,920 ingots of Banca, and 900 ingots of Billiton. The deliveries now *en route* of the two descriptions are 39,260 ingots, and 9518 ingots, against 184,539 ingots and 32,000 ingots in 1868. These totals appear to point to the probability of an advance of some importance. The last mail from the Dutch Indies announced that the production of Banca for 1868 was 66,210 piculs (about 132,000 ingots), or 6000 piculs more than had previously named as the probable production of the year. Lead has been firm at Havre; at Havre the tendency is also in the direction of continued firmness. At Hamburg prices have been well maintained. At Rotterdam, Stolberg and Eschweiler has brought 37⅜ fls. Zinc remains without much alteration in value.

SALES OF COPPER ORES.

COPPER ORES SOLD AT THE CORNWALL TICKETINGS FOR THE QUARTER ENDING MARCH, 1869:—

Mines.	Tons.	Amount.		
Devon Great Consols	4254	£17,038	18	6
South Caradon	1552	12,966	11	6
Marke Valley	1499	5,770	13	6
West Seton	1136	5,678	1	6
Clifford Amalgamated	1130	3,517	16	0
Phoenix	591	2,945	19	6
East Caradon	613	2,839	2	6
Glasgow Caradon	577	2,420	4	6
Wheal Seton	703	2,292	15	6
Poldice	506	2,139	9	0
Kelly Bray	369	2,089	5	0
Bampfylde	360	1,718	13	0
West Basset	463	1,636	1	0
Prince of Wales	315	1,566	6	6
Carn Brea	309	1,522	10	6
South Crofty	413	1,398	7	6
Wheal Crelake	458	1,392	0	6
Gunnislake	201	1,358	12	0
North Treskerby	274	1,355	11	0
Wheal Basset	270	1,343	19	0
East Rosewarne	314	1,316	7	0
West Maria and Fortescue	375	1,229	7	0
Okel Tor	211	1,186	8	0
Craddock Moor	244	1,167	18	6
Crenver and Abraham	452	1,167	0	6
Great North Downs	265	1,156	10	6
Bedford United	303	1,061	5	6
East Pool	307	1,010	19	0
Wheal Friendship	225	965	18	6
West Tolgus	213	928	1	0
West Caradon	187	847	8	6
East Grenville	165	770	12	6
North Downs	110	711	7	0
West Wheal Damsel	158	631	8	0
Gawton	150	600	0	0
Wheal Emily Henrietta	105	590	16	6
Prosper United	179	575	9	0
Copper Hill	147	505	9	0
Par Consols	137	479	4	6
South Wheal Frances	78	442	12	0
Gonamena	81	415	9	6
Levant	47	415	9	0
Botallack	49	410	11	6
East Carn Brea	135	386	9	6
East Basset	38	359	3	0
Belstone	61	333	4	0
New Treleigh	92	311	10	6
Wheal Rose	75	295	10	6
North Roskear	54	290	5	0
South Condurrow	29	245	1	0
Tincroft	53	218	16	0
Wheal Crebor	60	200	2	0
Wheal Buller	38	195	18	0
East Russell	50	182	15	0
Brookwood	80	176	8	0
Wheal Russell	53	176	4	6
Carn Camborne	60	152	0	0
Dolcoath	30	143	5	0
Wheal Courtenay	25	140	12	6
Tresavean	35	138	10	0
Tywarnhaile	37	110	14	0
Pennance	40	101	0	0
Wheal Mary Florence	33	93	4	6
Wheal Kitty	15	86	12	6
West Tremayne	23	81	1	6
North Pool	14	80	3	0
Tresevean	25	50	12	6
Bugleholе's Ore	12	48	12	0
South Polmear	25	45	12	6
Rosewarne Consols	6	39	9	0
Treven	7	39	4	0
Sortridge Consols	10	33	5	0
South Dolcoath	12	31	10	0
North Grambler	7	26	12	0
Fanny Adela	13	24	14	0
Maudlin	11	22	5	0
Huthnance's Ore	7	10	10	0
Great Crinnis	2	6	11	0

COMPANIES BY WHOM THE ORES WERE PURCHASED.

Vivian and Sons	3757	£14,717	18	9
Freeman and Co.	1520	7,092	1	3
P. Grenfell and Sons	2422	15,139	11	5
Sims, Willyams, and Co.	2350	13,385	8	11
Williams, Foster, and Co.	3843	18,396	18	5
Mason and Elkington	3091	11,174	8	1
Bankart and Sons	1245	3,434	5	6
Copper Miners' Company	2021	7,612	5	3
Charles Lambert	311	998	9	0
Sweetland, Tuttle, and Co.	1274	4,355	11	0
Goole Alum Company	46	127	13	0
Total	21,870	£96,464	1	0

SALES OF COPPER ORES.

COPPER ORES SOLD AT THE CORNISH TICKETINGS FOR THE QUARTER ENDING MARCH, 1869:—

Mines.	Tons.	Amount.		
BRITISH.				
Berehaven	802	£ 5,162	12	6
Knockmahon	191	1,412	2	0
Bradda	65	780	2	6
Ballycummisk	74	502	10	0
Tigrony	28	338	11	0
Cawsand Vale	75	223	2	6
Total	1235	£ 8,219	0	6
COLONIAL.				
Cape	586	£13,779	16	6
Union Mine, Tilt Cove	1216	6,795	13	0
Wallaroo	204	1,384	5	0
Moonta	116	1,355	14	6
Paramatta	92	1,147	13	6
Concordia	24	321	11	0
Total	2238	£21,784	13	6
FOREIGN.				
Cuba	500	£ 7,787	4	6
Azambugeira	48	1,066	9	0
Spanish	104	561	8	0
Lisbon	31	536	0	0
French	44	183	12	0
Pomona	3	89	19	0
Total	730	£10,224	12	6
RECAPITULATION.				
British	1235	£ 8,219	0	6
Colonial	2238	24,784	13	6
Foreign	730	10,224	12	6
Regulus, sludge, and sundries	217	1,442	14	0
Total	4420	£44,671	0	6

COMPANIES BY WHOM THE ORES WERE PURCHASED:—

Copper Miners' Company	387	£ 2,699	14	6
Freeman and Co.	395	4,313	7	3
P. Grenfell and Sons	325	4,654	2	6
Sims, Willyams, & Co.	418	5,561	12	6
Vivian and Sons	959	4,581	13	3
Williams, Foster, and Co.	943	9,583	10	9
Mason and Elkington	580	7,267	6	6
Bankart and Sons	116	1,848	2	0
Sweetland, Tuttle, and Co.	296	4,131	11	3
Total	4420	£44,671	0	6

FOREIGN MINES.

DON PEDRO.—The following telegram has this morning (April 1) been received:—Produce cleaned to March 1, 15,819 oits.; estimate for February, 18,000 oits.

FRONTINO AND BOLIVIA (South American) GOLD.—The directors have received advices from their superintendent, dated New Granada, Feb. 15, by which it appears that the return for January was 598 ozs. of gold.

UNITED MEXICAN.—Guanaxuato, Feb. 22: Mine of Jesus Maria y Jose: The only change worthy of note is an improvement in our lowest frente, going off N.W., called San Lucas. The amount of ore sent to the haciendas has been sufficient to keep them at full work, and the buscone sales have been for the three weeks ending February 18, $4662. The accounts for the month of January show an excess in outlay of $5060, but our tortas in Duran have been thrown back by the cold weather, and the gold from the ores ground in January will not come in till March.—Mines in the Guadalupe de la Oscura District: In this district matters are looking more promising. In Encinillas the ore found at the end of last month near the planes (deepest workings) of El Oro continues, and we are opening out on it. In January our outlay was $818, against returns estimated at $621. In February I hope that our accounts may show a small profit, and if the ore continue as we advance we may reasonably hope for better results. The lode gets broader as we go down on it, but is very hard.—New Mines: The San Cayetano adit advanced in January 5½ varas. The rock is extremely hard, and we have cut no vein stuff in the month. In Buenos Ayres shaft we have reached a depth of nearly 34 varas. We have cut in it a small strip of quartzoze rock containing silver, in itself of no value, but favourable as an indication of the ground being far from barren. In San Antonio de la Ovejera the malacate (horse whim) is constructed, and at work. The shaft drained and cleared of old timber and other debris is found to be 83½ varas deep. The workmen commenced on its continuation on Feb. 18, and we are in very loose ground, which though favourable for driving will give some trouble afterwards in securing it either with mason work or timber.

MARIQUITA.—Mr. Treffry (Feb. 19) writes—Santa Ana: Ore drawn to date, 761 skips. The hand selection has yielded well during the past two days, and I trust our produce will not fall short in proportion to that of January.—Feb. 20: Now that we have driven a little on Treffry's lode we have been able to dial it, and I have no doubt now that it is, as I represented it in one of my sketch plans, a continuation south of the great northern lode, and is consequently the Santana western lode, which was worked upon south of the flookan, by stoping down to the 60, when, by driving north through the flookan, we got the rich lode between the 50 and 70 fm. levels. But below this point the workings, south of the flookan, have been carried back on the main lode. By next mail I shall have checked my observations, and have prepared a correct plan and sections, showing clearly the facts of the case; this lode continues as good as ever, and widening. In the cross-cut at the 120 we cannot be far off it, and have already cut some of its branches.—Marmato Mines for the month of Jan.: Cost, $9710; returns, $10,489.—Cost and Returns: The dry weather which has prevailed throughout the month still continues without indication of abatement, and as a matter of course has operated against the returns for January.—Aquas Claras for the month of January: Cost, $2377; returns, $2699.

IMPERIAL SILVER QUARRIES.—Mr. Chalmers, Feb. 1, writes that he was unable to obtain possession of the property until Feb. 16, 1868, when he forthwith advertised for tenders for running the first 150 ft. of tunnel, and accepted one at $12·45, not to include track, timber, or ventilation; an additional 310 ft. was run at $13·37. The ventilation cost $498·29, track $106·64, and ironing same $140·50. The ventilation is carried on by means of a 6-in. galvanised-iron pipe, the tunnel being too small to admit of pipes of the usual size being used. A blacksmith's shop, manager's house, with assay office and laboratory, &c., have been built. A mill site and water privilege have been obtained for 130l. He confirms all he has said with regard to the value of the property, provided the necessary capital be forthcoming for its development.

PESTARENA UNITED.—T. Roberts, T. Warne, March 26: The lode in the end of the 46, driving south from Aquavite engine-shaft, has further improved. We had another separate trial of the ore from this end yesterday with 26 small mills, we calculate, "from the amalgam we obtained," it to give after the rate of 1½ ozs. of gold per ton, and estimate this end to yield 8 tons of ore per fathom, or 12 ozs. of gold. The stopes in back of the 23 south are not looking so well in rising. No important change in any other places to notice. During the month we have had occasionally falls of snow. At Pestarena the surface is yet covered with 20 in. of snow, which has disappointed us in resuming the surface works. So far as gone this month we have not be able to bring down any ore from the Cani Mine. Nothing new at Val Toppa. We shall send you a report, as usual, after the smelting of the amalgam, which we intend to make on April 1.

VAL ANTIGORIA.—Thomas Roberts, March 23: At our No. 2 lode the winze is down for a 30 fathom level, and we have commenced driving south. The lode in the end produces some ore, but we expect it to increase in this driving, as in sinking the winze we passed through a pretty fair lode of ore, inclining southward, and the line of it is yet before the end. The end driving north in the 20, on this lode, is not looking so well. The stopes in the back of the 20, on No. 1, south of main winze, yields 2 tons of ore per fathom. The lode in the adit end, driving north, is poor at present. We have not completed the clearing out of the old, or second cross-cut, mentioned in my last, but have succeeded in getting into the end of it, where we find it has reached a junction, or the underside of a bed or lode of inferior marble, and at this junction stones of quartz, with some pyrites—very likely auriferous. We shall make a trial of it with a small mill. On the other side of this marble we may expect another change, and near it the gneiss rock. Nothing new on surface exploring.

[For remainder of Foreign Mines, see this day's Journal.]

METALLIC ROPES.—Mr. H. Henson-Henson, of Parliament-street, Westminster, has invented an improved construction of metallic ropes, such as are used in mines, for the rigging of ships, and other purposes, whereby greater safety and strength will be insured, and the great danger to ships from the effects of the electric fluid will be rendered more remote. Wire-rope, as at present in general use, is made of galvanised iron wire of a fine gauge, which being unprotected suffers much from abrasion, corrosion, and consequent fracturing, in addition to which it is said that by th process of galvanising the wire, through being heated to a high temperature, loses 25 per cent. of its strength. Mr. Henson's invention consists in employing the wires for such ropes in their natural ungalvanised and, consequently, unweakened state, and providing them either before or during the process of rope making with a protective coating of tape, jute, hemp, or other suitable fibre or fabric, either alone or combined with "Hay's glue," carbonised oil, or some other suitable bituminous or other material or compound that will effectually exclude moisture and grit. Or in place of, or in addition to, coating each wire separately, the fibrous substance, with or without bituminous or other matter, may be introduced between the wires of the rope during the process of rope-making, so that each wire is more or less entirely embedded in such fibrous and bituminous matter, and is thus effectually preserved and protected against undue straining, the fibrous matter forming an elastic cushion for the same, and preventing the fracture of numerous wires in the rope, such as occurs in ropes of present construction. By the use of these improved wire-ropes the danger and expense arising from the decay and breakage of wire-ropes, as at present made, will be more or less entirely obviated, whether such improved ropes are used in coal or other mines, for ships, or other purposes, and when employed for ships' rigging the non-conducting coating of the rope will more or less entirely protect it from the action of the electric fluid, the rope being at the same time air and water proof, more ductile, and, consequently, safer than the wire-ropes now employed.

THE GREAT RAILWAY SYSTEMS.—The London and North-Western is the oldest of the great railway systems, dating from the Liverpool and Manchester line as the parent germ, and coming down to the amalgamation, in 1864, of the Grand Junction, the Manchester and Birmingham, and the London and Birmingham. This system has never lost its lead as in different respects the greatest of our railway systems. In mileage, about 1400 miles, the Great Western comes nearest to it, but it and all others fall short of the London and North-Western in miles run by trains, in revenue, and in other respects. In 1867 the miles run by trains were as follows:—London and North-Western, 22,269,542 miles, revenue, 6,752,567l.; Great Western, 14,157,224 miles, revenue, 3,911,519l.; North Eastern, 15,548,099 miles, revenue, 3,804,220l.; Midland, 13,084,287 miles, revenue, 3,139,855l.; Great Northern, 9,115,204 miles, revenue, 2,112,150l.; Great Eastern, 6,835,163 miles, revenue, 1,915,481l.; Lancashire and Yorkshire, 8,227,128 miles, revenue, 8,227,128l. As regards rolling stock of the companies just named in 1867, the London and North Western had 1443 locomotives; the Great Western, 842; the North-Eastern, 851; the Midland, 623; the Great Northern, 468; the Great Eastern, 380; and the Lancashire and Yorkshire, 455.—*The Engineer.*

SCIENCE AND ART.—A striking instance of the immense value a small piece of steel may acquire by the great power of skilled mechanical labour is the balance-spring of a watch. From its extreme fineness and delicacy 4000 weigh not more than one ounce, and exceed in value 1000l. A most interesting little work, describing the rise and progress of watchmaking, has been published by Mr. J. W. Benson, 25, Old Bond Street, and the City Steam Factory, 58 and 60, Ludgate Hill. The book, which is profusely illustrated, gives a full description of the various kinds of watches and clocks, with their prices. Mr. Benson (who holds the appointment to the Prince of Wales) has also published a pamphlet on Artistic Gold Jewellery, illustrated with the most beautiful designs of Bracelets, Brooches, Earrings, Lockets, &c., suitable for Wedding, Birthday, and other presents. These pamphlets are sent post free for two stamps each, and they cannot be too strongly recommended to those contemplating a purchase, especially to residents in the country or abroad, who are thus enabled to select any article they may require, and have it forwarded with perfect safety.

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